Appendix I

Conversion of units

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Conversion of units refers to **conversion factors** between different units of measurement for the same quantity.

Contents

Techniques

Process

The process of conversion depends on the specific situation and the intended purpose. This may be governed by regulation, contract, Technical specifications or other published standards. Engineering judgment may include such factors as:

- The precision and accuracy of measurement and the associated uncertainty of measurement
- The statistical confidence interval or tolerance interval of the initial measurement
- The number of significant figures of the measurement
- The intended use of the measurement including the engineering tolerances

Some conversions from one system of units to another need to be exact, without increasing or decreasing the precision of the first measurement. This is sometimes called *soft conversion*. It does not involve changing the physical configuration of the item being measured.

By contrast, a *hard conversion* or an *adaptive conversion* may not be exactly equivalent. It changes the measurement to convenient and workable numbers and units in the new system. It sometimes involves a slightly different configuration, or size substitution, of the item.

Multiplication Factors

Conversion between units in the metric (SI) system can be discerned by their prefixes (for example, 1 kilogram = 1000 grams, 1 milligram = 0.001 grams) and are thus not listed in this article. Exceptions are made if the unit is commonly known by another name (for example, 1 micron = 10^{-6} metre). For a full listing of multiplication factors, see SI prefix.

Table Ordering

Within each table, the units are listed alphabetically, and the SI units (base or derived) are highlighted.

Tables of conversion factors

This article gives lists of conversion factors for each of a number of physical quantities, which are listed in the index. For each physical quantity, a number of different units (some only of historical interest) are shown and expressed in terms of the corresponding SI unit.

Legend

Symbol	Definition
≡	exactly equal to
≈	approximately equal to
$\overline{\textit{digits}}$	indicates that *digits* repeat infinitely (e.g. 8.294 $\overline{369}$ corresponds to 8.294 369 369 369 369…)
(H)	of chiefly historical interest

Length

Length

Name of unit	Symbol	Definition	Relation to SI units
ångström	Å	≡ 1×10^{-10} m	≡ 0.1 nm
astronomical unit	AU	≈ Distance from Earth to Sun	≈ 149 597 871 464 m [1]
barleycorn (H)		≡ ⅓ in (see note above about rounding)	≈ $8.4\overline{6} \times 10^{-3}$ m
bohr, atomic unit of length	a_0	≡ Bohr radius of hydrogen	≈ $5.291\,772\,0859 \times 10^{-11} \pm 3.6 \times 10^{-20}$ m [2]
cable length (Imperial)		≡ 608 ft	≈ 185.3184 m
cable length (International)		≡ 1/10 nmi	≡ 185.2 m
cable length (U.S.)		≡ 720 ft	≡ 219.456 m
chain (Gunter's; Surveyor's)	ch	≡ 66 ft(US) ≡ 4 rods [3]	≈ 20.116 84 m
cubit (H)		≡ Distance from fingers to elbow ≈ 18in	≈ 0.5 m
ell (H)	ell	≡ 45 in [4] (In England usually)	≡ 1.143 m
fathom	fm	≡ 6 ft [4]	≡ 1.8288 m
fermi	fm	≡ 1×10^{-15} m [4]	≡ 1×10^{-15} m
finger		≡ 7/8 in	≡ 0.022 225 m
finger (cloth)		≡ 4½ in	≡ 0.1143 m
foot (Benoît) (H)	ft (Ben)		≈ 0.304 799 735 m
foot (Clarke's; Cape) (H)	ft (Cla)		≈ 0.304 797 2654 m
foot (Indian) (H)	ft Ind		≈ 0.304 799 514 m
foot (International)	ft	≡ 1/3 yd ≡ 0.3048 m ≡ 12 inches	≡ 0.3048 m

foot (Sear's) (H)	ft (Sear)		≈ 0.304 799 47 m
foot (U.S. Survey)	ft (US)	≡ 1200/3937 m [5]	≈ 0.304 800 610 m
french; charriere	F	≡ ⅓ mm	= 3.3×10^{-4} m
furlong	fur	≡ 10 chains = 660 ft = 220 yd [4]	= 201.168 m
hand		≡ 4 in [4]	≡ 0.1016 m
inch (International)	in	≡ 1/36 yd ≡ 1/12 ft	≡ 0.0254 m
league (land)	lea	≡ 3 US Statute miles [3]	= 4 828.032 m
light-day		≡ 24 light-hours	≡ $2.590\ 206\ 837\ 12 \times 10^{13}$ m
light-hour		≡ 60 light-minutes	≡ $1.079\ 252\ 8488 \times 10^{12}$ m
light-minute		≡ 60 light-seconds	≡ $1.798\ 754\ 748 \times 10^{10}$ m
light-second		≡ Distance light travels in one second in vacuum	≡ 299 792 458 m
light-year	l.y.	≡ Distance light travels in vacuum in 365.25 days [6]	= $9.460\ 730\ 472\ 5808 \times 10^{15}$ m
line	ln	≡ 1/12 in [7]	= 0.002 116 m
link (Gunter's; Surveyor's)	lnk	≡ 1/100 ch [4] ≡ 0.66 ft ≡ 7.92in	= 0.201 168 m
link (Ramsden's; Engineer's)	lnk	≡ 1 ft [4]	= 0.3048 m
metre (SI base unit)	m	≡ Distance light travels in 1/299 792 458 of a second in vacuum.[8] ≈ distance from equator to pole/10 000 000	≡ 1 m
mickey		≡ 1/200 in	= 1.27×10^{-4} m
micron	μ		≡ 1×10^{-6} m
mil; thou	mil	≡ 1×10^{-3} in	≡ 2.54×10^{-5} m
mil (Sweden and Norway)	mil	≡ 10 km	= 10 000 m
mile (geographical) (H)		≡ 6082 ft	= 1 853.7936 m
mile (international)	mi	≡ 80 chains ≡ 5280 ft ≡ 1760 yd	≡ 1 609.344 m
mile (tactical or data)		≡ 6000 ft	≡ 1828.8 m
mile (telegraph) (H)	mi	≡ 6087 ft	= 1 855.3176 m

mile (U.S. Survey)	mi	≡ 5280 *ft* (US Survey feet) ≡ (5280 × 1200/3937) m	≈ 1 609.347 219 m
nail (cloth)		≡ 2¼ in [4]	= 0.057 15 m
nautical league	NL; nl	≡ 3 nmi [4]	= 5556 m
nautical mile (Admiralty)	NM (Adm); nmi (Adm)	= 6080 ft	= 1853.184 m
nautical mile (international)	NM; nmi	≡ 1852 m [9]	≡ 1852 m
nautical mile (US pre 1954)		≡ 1853.248 m	≡ 1853.248 m
pace		≡ 2.5 ft [4]	= 0.762 m
palm		≡ 3 in [4]	= 0.0762 m
parsec	pc	Distance of star with ***par***allax shift of one arc ***sec***ond from a base of one astronomical unit	≈ $3.085\ 677\ 82 \times 10^{16} \pm 6 \times 10^{6}$ m [10]
pica		≡ 12 points	Dependent on point measures.
point (American, English) [11][12]	pt	≡ 1/72.272 in	≈ 0.000 351 450 m
point (Didot; European) [12][13]	pt	≡ 1/12 × 1/72 of pied du roi; After 1878: ≡ 5/133 cm	≈ 0.000 375 97 m; After 1878: ≈ 0.000 375 939 85 m
point (PostScript) [11]	pt	≡ 1/72 in	= $0.000\ 352\ \overline{7}$ m
point (TeX) [11]	pt	≡ 1/72.27 in	= 0.000 351 4598 m
quarter		≡ ¼ yd	= 0.2286 m
rod; pole; perch (H)	rd	≡ 16½ ft	= 5.0292 m
rope (H)	rope	≡ 20 ft [4]	= 6.096 m
span (H)		≡ 9 in [4]	= 0.2286 m
spat [14]			≡ 1×10^{12} m
stick (H)		≡ 2 in	= 0.0508 m
stigma; bicron (picometre)	pm		≡ 1×10^{-12} m
twip	twp	≡ 1/1440 in	= 1.7638×10^{-5} m
x unit; siegbahn	xu		≈ 1.0021×10^{-13} m [4]
yard			

(International)	yd	≡ 0.9144 m [5] ≡ 3 ft ≡ 36 in	≡ 0.9144 m

Area

Area

Name of unit	Symbol	Definition	Relation to SI units
acre (international)	ac	≡ 1 ch × 10 ch = 4840 sq yd	≡ 4 046.856 4224 m^2
acre (U. S. survey)	ac	≡ 10 sq ch = 4840 sq yd	≈ 4 046.873 m^2 [15]
are	a	≡ 100 m^2	= 100 m^2
barn	b	≡ 10^{-28} m^2	= 10^{-28} m^2
barony		≡ 4000 ac	≈ 1.618 742 × 10^7 m^2
board	bd	≡ 1 in × 1 ft	= 7.741 92 × 10^{-3} m^2
boiler horsepower equivalent direct radiation	bhp EDR	≡ (1 ft^2) (1 bhp) / (240 BTU_{IT}/h)	≈ 12.958 174 m^2
circular inch	circ in	≡ π/4 sq in	≈ 5.067 075 × 10^{-4} m^2
circular mil; circular thou	circ mil	≡ π/4 mil^2	≈ 5.067 075 × 10^{-10} m^2
cord		≡ 192 bd	= 1.486 448 64 m^2
dunam		≡ 1 000 m^2	= 1 000 m^2
guntha		≡ 121 sq yd	≈ 101.17 m^2
hectare	ha	≡ 10 000 m^2	≡ 10 000 m^2
hide		≈ 120 ac (variable)	≈ 5 × 10^5 m^2
rood	ro	≡ ¼ ac	= 1 011.714 1056 m^2
section		≡ 1 mi × 1 mi	= 2.589 988 110 336 × 10^6 m^2
shed		≡ 10^{-52} m^2	= 10^{-52} m^2
square (roofing)		≡ 10 ft × 10 ft	= 9.290 304 m^2
square chain (international)	sq ch	≡ 66 ft × 66 ft = 1/10 ac	≡ 404.685 642 24 m^2
square chain (U.S. Survey)	sq ch	≡ 66 ft(US) × 66 ft(US) = 1/10 ac	≈ 404.687 3 m^2
square foot	sq ft	≡ 1 ft × 1 ft	≡ 9.290 304 × 10^{-2} m^2
square foot (U.S. Survey)	sq ft	≡ 1 ft (US) × 1 ft (US)	≈ 9.290 341 161 327 49 × 10^{-2} m^2
square inch	sq in	≡ 1 in × 1 in	≡ 6.4516 × 10^{-4} m^2
square kilometre	km^2	≡ 1 km × 1 km	= 10^6 m^2

square link (Gunter's) (International)	sq lnk	≡ 1 lnk × 1 lnk ≡ 0.66 ft × 0.66 ft	= $4.046\ 856\ 4224 \times 10^{-2}$ m^2
square link (Gunter's)(US Survey)	sq lnk	≡ 1 lnk × 1 lnk ≡ 0.66 ft (US) × 0.66 ft(US)	≈ $4.046\ 872 \times 10^{-2}$ m^2
square link (Ramsden's)	sq lnk	≡ 1 lnk × 1 lnk ≡ 1 ft × 1 ft	= 0.09290304 m^2
square metre (SI unit)	m^2	≡ 1 m × 1 m	= 1 m^2
square mil; square thou	sq mil	≡ 1 mil × 1 mil	= 6.4516×10^{-10} m^2
square mile	sq mi	≡ 1 mi × 1 mi	= $2.589\ 988\ 110\ 336 \times 10^{6}$ m^2
square mile (U.S. Survey)	sq mi	≡ 1 mi (US) × 1 mi (US)	≈ $2.589\ 998\ 47 \times 10^{6}$ m^2
square rod/pole/perch	sq rd	≡ 1 rd × 1 rd	= 25.292 852 64 m^2
square yard (International)	sq yd	≡ 1 yd × 1 yd	≡ 0.836 127 36 m^2
stremma		≡ 1 000 m^2	= 1 000 m^2
township		≡ 36 sq mi (US)	≈ $9.323\ 994 \times 10^{7}$ m^2
yardland		≈ 30 ac	≈ 1.2×10^{5} m^2

Volume

Volume

Name of unit	Symbol	Definition	Relation to SI units
acre-foot	ac ft	≡ 1 ac x 1 ft = 43 560 ft^3	= 1 233.481 837 547 52 m^3
acre-inch		≡ 1 ac × 1 in	= 102.790 153 128 96 m^3
barrel (Imperial)	bl (Imp)	≡ 36 gal (Imp)	= 0.163 659 24 m^3
barrel (petroleum)	bl; bbl	≡ 42 gal (US)	= 0.158 987 294 928 m^3
barrel (U.S. dry)	bl (US)	≡ 105 qt (US) = 105/32 bu (US lvl)	= 0.115 628 198 985 075 m^3
barrel (U.S. fluid)	fl bl (US)	≡ 31½ gal (US)	= 0.119 240 471 196 m^3
board-foot	fbm	≡ 144 cu in	≡ $2.359\ 737\ 216 \times 10^{-3}$ m^3
bucket (Imperial)	bkt	≡ 4 gal (Imp)	= 0.018 184 36 m^3
bushel (Imperial)	bu (Imp)	≡ 8 gal (Imp)	= 0.036 368 72 m^3
bushel (U.S. dry heaped)	bu (US)	≡ 1 ¼ bu (US lvl)	= 0.044 048 837 7086 m^3
bushel (U.S. dry level)	bu (US lvl)	≡ 2 150.42 cu in	= 0.035 239 070 166 88 m^3
butt, pipe		≡ 126 gal (wine)	= 0.476 961 884 784 m^3
coomb		≡ 4 bu (Imp)	= 0.145 474 88 m^3

cord (firewood)		≡ 8 ft × 4 ft × 4 ft	$= 3.624\ 556\ 363\ 776\ \text{m}^3$
cord-foot		≡ 16 cu ft	$= 0.453\ 069\ 545\ 472\ \text{m}^3$
cubic fathom	cu fm	≡ 1 fm × 1 fm × 1 fm	$= 6.116\ 438\ 863\ 872\ \text{m}^3$
cubic foot	cu ft	≡ 1 ft × 1 ft × 1 ft	$\equiv 0.028\ 316\ 846\ 592\ \text{m}^3$
cubic inch	cu in	≡ 1 in × 1 in × 1 in	$\equiv 16.387\ 064 \times 10^{-6}\ \text{m}^3$
cubic metre (SI unit)	m^3	≡ 1 m × 1 m × 1 m	$\equiv 1\ \text{m}^3$
cubic mile	cu mi	≡ 1 mi × 1 mi × 1 mi	$\equiv 4\ 168\ 181\ 825.440\ 579\ 584\ \text{m}^3$
cubic yard	cu yd	≡ 27 cu ft	$\equiv 0.764\ 554\ 857\ 984\ \text{m}^3$
cup (breakfast)		≡ 10 fl oz (Imp)	$= 284.130\ 625 \times 10^{-6}\ \text{m}^3$
cup (Canadian)	c (CA)	≡ 8 fl oz (Imp)	$= 227.3045 \times 10^{-6}\ \text{m}^3$
cup (metric)	c	$\equiv 250.0 \times 10^{-6}\ \text{m}^3$	$= 250.0 \times 10^{-6}\ \text{m}^3$
cup (U.S. customary)	c (US)	≡ 8 US fl oz ≡ 1/16 gal (US)	$= 236.588\ 2365 \times 10^{-6}\ \text{m}^3$
cup (U.S. food nutrition labeling)	c (US)	≡ 240 mL[16]	$= 2.4 \times 10^{-4}\ \text{m}^3$
dash (Imperial)		≡ 1/384 gi (Imp) = ½ pinch (Imp)	$= 369.961\ 751\ 302\ 08\ \overline{3} \times 10^{-9}\ \text{m}^3$
dash (U.S.)		≡ 1/96 US fl oz = ½ US pinch	$= 308.057\ 599\ 609\ 375 \times 10^{-9}\ \text{m}^3$
dessertspoon (Imperial)		≡ 1/12 gi (Imp)	$= 11.838\ 776\ 041\overline{6} \times 10^{-6}\ \text{m}^3$
drop (Imperial)	gtt	≡ 1/288 fl oz (Imp)	$= 98.656\ 467\ 013\ \overline{8} \times 10^{-9}\ \text{m}^3$
drop (Imperial) (alt)	gtt	≡ 1/1 824 gi (Imp)	$\approx 77.886\ 684 \times 10^{-9}\ \text{m}^3$
drop (medical)		≡ 1/12 ml	$= 83.0\overline{3} \times 10^{-9}\ \text{m}^3$
drop (metric)		≡ 1/20 mL	$= 50.0 \times 10^{-9}\ \text{m}^3$
drop (U.S.)	gtt	≡ 1/360 US fl oz	$= 82.148\ 693\ 2291\overline{6} \times 10^{-9}\ \text{m}^3$
drop (U.S.) (alt)	gtt	≡ 1/456 US fl oz	$\approx 64.854\ 231 \times 10^{-9}\ \text{m}^3$
fifth		≡ 1/5 US gal	$= 757.082\ 3568 \times 10^{-6}\ \text{m}^3$
firkin		≡ 9 gal (US)	$= 0.034\ 068\ 706\ 056\ \text{m}^3$
fluid drachm (Imperial)	fl dr	≡ ⅛ fl oz (Imp)	$= 3.551\ 632\ 8125 \times 10^{-6}\ \text{m}^3$
fluid dram (U.S.); U.S. fluidram	fl dr	≡ ⅛ US fl oz	$= 3.696\ 691\ 195\ 3125 \times 10^{-6}\ \text{m}^3$
fluid scruple (Imperial)	fl s	≡ 1/24 fl oz (Imp)	$= 1.183\ 877\ 6041\overline{6} \times 10^{-6}\ \text{m}^3$
gallon (beer)	beer gal	≡ 282 cu in	$= 4.621\ 152\ 048 \times 10^{-3}\ \text{m}^3$

gallon (Imperial)	gal (Imp)	≡ 4.546 09 L	≡ 4.546 09 × 10^{-3} m^3
gallon (U.S. dry)	gal (US)	≡ ⅛ bu (US lvl)	= 4.404 883 770 86 × 10^{-3} m^3
gallon (U.S. fluid; Wine)	gal (US)	≡ 231 cu in	≡ 3.785 411 784 × 10^{-3} m^3
gill (Imperial); Noggin	gi (Imp); nog	≡ 5 fl oz (Imp)	= 142.065 3125 × 10^{-6} m^3
gill (U.S.)	gi (US)	≡ 4 US fl oz	= 118.294 118 25 × 10^{-6} m^3
hogshead (Imperial)	hhd (Imp)	≡ 2 bl (Imp)	= 0.327 318 48 m^3
hogshead (U.S.)	hhd (US)	≡ 2 fl bl (US)	= 0.238 480 942 392 m^3
jigger (bartending)		≡ 1½ US fl oz	≈ 44.36 × 10^{-6} m^3
kilderkin		≡ 18 gal (Imp)	= 0.081 829 62 m^3
lambda	λ	≡ 1 mm^3	= 1 × 10^{-9} m^3
last		≡ 80 bu (Imp)	= 2.909 4976 m^3
litre	L	≡ 1 dm^3 [17]	≡ 0.001 m^3
load		≡ 50 cu ft	= 1.415 842 3296 m^3
minim (Imperial)	min	≡ 1/480 fl oz (Imp) = 1/60 fl dr (Imp)	= 59.193 880 208 $\overline{3}$ × 10^{-9} m^3
minim (U.S.)	min	≡ 1/480 US fl oz = 1/60 US fl dr	= 61.611 519 921 875 × 10^{-9} m^3
ounce (fluid Imperial)	fl oz (Imp)	≡ 1/160 gal (Imp)	≡ 28.413 0625 × 10^{-6} m^3
ounce (fluid U.S. customary)	US fl oz	≡ 1/128 gal (US)	≡ 29.573 529 5625 × 10^{-6} m^3
ounce (fluid U.S. food nutrition labeling)	US fl oz	≡ 30 mL[16]	≡ 3 × 10^{-5} m^3
peck (Imperial)	pk	≡ 2 gal (Imp)	= 9.092 18 × 10^{-3} m^3
peck (U.S. dry)	pk	≡ ¼ US lvl bu	= 8.809 767 541 72 × 10^{-3} m^3
perch	per	≡ 16½ ft × 1½ ft × 1 ft	= 0.700 841 953 152 m^3
pinch (Imperial)		≡ 1/192 gi (Imp) = ⅛ tsp (Imp)	= 739.923 502 6041$\overline{6}$ × 10^{-9} m^3
pinch (U.S.)		≡ 1/48 US fl oz = ⅛ US tsp	= 616.115 199 218 75 × 10^{-9} m^3
pint (Imperial)	pt (Imp)	≡ ⅛ gal (Imp)	= 568.261 25 × 10^{-6} m^3
pint (U.S. dry)	pt (US dry)	≡ 1/64 bu (US lvl) ≡ ⅛ gal (US dry)	= 550.610 471 3575 × 10^{-6} m^3
pint (U.S. fluid)	pt (US fl)	≡ ⅛ gal (US)	= 473.176 473 × 10^{-6} m^3

pony		≡ 3/4 US fl oz	$= 22.180\ 147\ 171\ 875 \times 10^{-6}\ m^3$
pottle; quartern		≡ ½ gal (Imp) = 80 fl oz (Imp)	$= 2.273\ 045 \times 10^{-3}\ m^3$
quart (Imperial)	qt (Imp)	≡ ¼ gal (Imp)	$= 1.136\ 5225 \times 10^{-3}\ m^3$
quart (U.S. dry)	qt (US)	≡ 1/32 bu (US lvl) = ¼ gal (US dry)	$= 1.101\ 220\ 942\ 715 \times 10^{-3}\ m^3$
quart (U.S. fluid)	qt (US)	≡ ¼ gal (US fl)	$= 946.352\ 946 \times 10^{-6}\ m^3$
quarter; pail		≡ 8 bu (Imp)	$= 0.290\ 949\ 76\ m^3$
register ton		≡ 100 cu ft	$= 2.831\ 684\ 6592\ m^3$
sack (Imperial); bag		≡ 3 bu (Imp)	$= 0.109\ 106\ 16\ m^3$[*citation needed*]
sack (U.S.)		≡ 3 bu (US lvl)	$= 0.105\ 717\ 210\ 500\ 64\ m^3$
seam		≡ 8 bu (US lvl)	$= 0.281\ 912\ 561\ 335\ 04\ m^3$ [*citation needed*]
shot		≡ 1 US fl oz	$\approx 29.57 \times 10^{-6}\ m^3$
strike (Imperial)		≡ 2 bu (Imp)	$= 0.072\ 737\ 44\ m^3$
strike (U.S.)		≡ 2 bu (US lvl)	$= 0.070\ 478\ 140\ 333\ 76\ m^3$
tablespoon (Canadian)	tbsp	≡ ½ fl oz (Imp)	$= 14.206\ 531\ 25 \times 10^{-6}\ m^3$
tablespoon (Imperial)	tbsp	≡ 5/8 fl oz (Imp)	$= 17.758\ 164\ 0625 \times 10^{-6}\ m^3$
tablespoon (metric)			$\equiv 15.0 \times 10^{-6}\ m^3$
tablespoon (U.S. customary)	tbsp	≡ ½ US fl oz	$= 14.786\ 764\ 7825 \times 10^{-6}\ m^3$
tablespoon (U.S. food nutrition labeling)	tbsp	≡ 15 mL[16]	$= 1.5 \times 10^{-5}\ m^3$
teaspoon (Canadian)	tsp	≡ 1/6 fl oz (Imp)	$= 4.735\ 510\ 41\bar{6} \times 10^{-6}\ m^3$
teaspoon (Imperial)	tsp	≡ 1/24 gi (Imp)	$= 5.919\ 388\ 020\bar{83} \times 10^{-6}\ m^3$
teaspoon (metric)		$\equiv 5.0 \times 10^{-6}\ m^3$	$= 5.0 \times 10^{-6}\ m^3$
teaspoon (U.S. customary)	tsp	≡ 1/6 US fl oz	$= 4.928\ 921\ 595 \times 10^{-6}\ m^3$
teaspoon (U.S. food nutrition labeling)	tsp	≡ 5 mL[16]	$= 5 \times 10^{-6}\ m^3$
timber foot		≡ 1 cu ft	$= 0.028\ 316\ 846\ 592\ m^3$
ton (displacement)		≡ 35 cu ft	$= 0.991\ 089\ 630\ 72\ m^3$
ton (freight)		≡ 40 cu ft	$= 1.132\ 673\ 863\ 68\ m^3$
ton (water)		≡ 28 bu (Imp)	$= 1.018\ 324\ 16\ m^3$
tun		≡ 252 gal (wine)	$= 0.953\ 923\ 769\ 568\ m^3$

wey (U.S.)	≡ 40 bu (US lvl)	= 1.409 562 806 6752 m^3

Plane angle

Plane angle

Name of unit	Symbol	Definition	Relation to SI units
angular mil	µ	≡ 2π/6400 rad	≈ 0.981 748 × 10^{-3} rad
arcminute	'	≡ 1°/60	≈ 0.290 888 × 10^{-3} rad
arcsecond	"	≡ 1°/3600	≈ 4.848 137 × 10^{-6} rad
centesimal minute of arc	'	≡ 1 grad/100	≈ 0.157 080 × 10^{-3} rad
centesimal second of arc	"	≡ 1 grad/(10 000)	≈ 1.570 796 × 10^{-6} rad
degree (of arc)	°	≡ 1/360 of a revolution ≡ π/180 rad	≈ 17.453 293 × 10^{-3} rad
grad; gradian; gon	grad	≡ 1/400 of a revolution ≡ 2π/400 rad ≡ 0.9°	≈ 15.707 963 × 10^{-3} rad
octant		≡ 45°	≈ 0.785 398 rad
quadrant		≡ 90°	≈ 1.570 796 rad
radian (SI unit)	rad	The angle subtended at the center of a circle by an arc whose length is equal to the circle's radius. One full revolution encompasses 2π radians.	= 1 rad
sextant		≡ 60°	≈ 1.047 198 rad
sign		≡ 30°	≈ 0.523 599 rad

Solid angle

Solid angle

Name of unit	Symbol	Definition	Relation to SI units
steradian (SI unit)	sr	The solid angle subtended at the center of a sphere of radius r by a portion of the surface of the sphere having an area r^2. A sphere encompasses 4π sr.[14]	= 1 sr

Mass

Notes:

- See Weight for detail of mass/weight distinction and conversion.
- In this table, the unit *gee* is used to denote standard gravity in order to avoid confusion with the "g" symbol for grams.

- In physics, the pound of mass is sometimes written **lbm** to distinguish it from the pound-force (**lbf**). It should not be read as the mongrel unit "pound metre".

Mass

Name of unit	Symbol	Definition	Relation to SI units
atomic mass unit, unified	u; AMU		≈ $1.660\,538\,73 \times 10^{-27} \pm 1.3 \times 10^{-36}$ kg
atomic unit of mass, electron rest mass	m_e		≈ $9.109\,382\,15 \times 10^{-31} \pm 45 \times 10^{-39}$ kg [18]
bag (coffee)		≡ 60 kg	= 60 kg
bag (Portland cement)		≡ 94 lb av	= 42.637 682 78 kg
barge		≡ 22½ sh tn	= 20 411.656 65 kg
carat	kt	≡ 3 1/6 gr	≈ 205.196 548 333 mg
carat (metric)	ct	≡ 200 mg	= 200 mg
clove		≡ 8 lb av	= 3.628 738 96 kg
crith			≈ 89.9349 mg
dalton	Da		≈ $1.660\,902\,10 \times 10^{-27} \pm 1.3 \times 10^{-36}$ kg
dram (apothecary; troy)	dr t	≡ 60 gr	= 3.887 9346 g
dram (avoirdupois)	dr av	≡ 27 11/32 gr	= 1.771 845 195 3125 g
electronvolt	eV	≡ 1 eV (energy unit) / c^2	= 1.7826×10^{-36} kg
gamma	γ	≡ 1 μg	= 1 μg
grain	gr	≡ 1/7000 lb av	≡ 64.798 91 mg
grave	G	grave was the original name of the kilogram	≡ 1 kg
hundredweight (long)	long cwt or cwt	≡ 112 lb av	= 50.802 345 44 kg
hundredweight (short); cental	sh cwt	≡ 100 lb av	= 45.359 237 kg
hyl (CGS unit)		≡ 1 gee × 1 g × 1 s^2/m	= 9.806 65 g
hyl (MKS unit)		≡ 1 gee × 1 kg × 1 s^2/m	= 9.806 65 kg
kilogram	kg	≡ mass of the prototype near Paris (≈ mass of 1L of water)	≡ 1 kg (SI base unit)[8]
kip	kip	≡ 1000 lb av	= 453.592 37 kg
mark		≡ 8 oz t	= 248.827 8144 g
mite		≡ 1/20 gr	= 3.239 9455 mg
mite (metric)		≡ 1/20 g	= 50 mg
ounce (apothecary; troy)	oz t	≡ 1/12 lb t	= 31.103 4768 g

ounce (avoirdupois)	oz av	≡ 1/16 lb	= 28.349 523 125 g
ounce (U.S. food nutrition labeling)	oz	≡ 28 g[16]	= 28 g
pennyweight	dwt; pwt	≡ 1/20 oz t	= 1.555 173 84 g
point		≡ 1/100 ct	= 2 mg
pound (avoirdupois)	lb av	≡ 0.453 592 37 kg = 7000 grains	≡ 0.453 592 37 kg
pound (metric)		≡ 500 g	= 500 g
pound (troy)	lb t	≡ 5 760 grains	= 0.373 241 7216 kg
quarter (Imperial)		≡ 1/4 long cwt = 2 st = 28 lb av	= 12.700 586 36 kg
quarter (informal)		≡ ¼ short tn	= 226.796 185 kg
quarter, long (informal)		≡ ¼ long tn	= 254.011 7272 kg
quintal (metric)	q	≡ 100 kg	= 100 kg
scruple (apothecary)	s ap	≡ 20 gr	= 1.295 9782 g
sheet		≡ 1/700 lb av	= 647.9891 mg
slug; geepound	slug	≡ 1 gee × 1 lb av × 1 s^2/ft	≈ 14.593 903 kg
stone	st	≡ 14 lb av	= 6.350 293 18 kg
ton, assay (long)	AT	≡ 1 mg × 1 long tn ÷ 1 oz t	≈ 32.666 667 g
ton, assay (short)	AT	≡ 1 mg × 1 sh tn ÷ 1 oz t	≈ 29.166 667 g
ton, long	long tn or ton	≡ 2 240 lb	= 1 016.046 9088 kg
ton, short	sh tn	≡ 2 000 lb	= 907.184 74 kg
tonne (mts unit)	t	≡ 1 000 kg	= 1 000 kg
wey		≡ 252 lb = 18 st	= 114.305 277 24 kg (variants exist)
Zentner	Ztr.	Definitions vary; see [19] and. [14]	

Density

Density

Name of unit	Symbol	Definition	Relation to SI units
gram per millilitre	g/mL	≡ g/mL	= 1,000 kg/m^3
kilogram per cubic metre (SI unit)	kg/m^3	≡ kg/m^3	= 1 kg/m^3
kilogram per litre	kg/L	≡ kg/L	= 1,000 kg/m^3
ounce (avoirdupois) per cubic foot	oz/ft^3	≡ oz/ft^3	≈ 1.001 153 961 kg/m^3
ounce (avoirdupois) per cubic inch	oz/in^3	≡ oz/in^3	≈ 1.729 994 044 × 10^3 kg/m^3

ounce (avoirdupois) per gallon (Imperial)	oz/gal	≡ oz/gal	≈ 6.236 023 291 kg/m^3
ounce (avoirdupois) per gallon (U.S. fluid)	oz/gal	≡ oz/gal	≈ 7.489 151 707 kg/m^3
pound (avoirdupois) per cubic foot	lb/ft^3	≡ lb/ft^3	≈ 16.018 463 37 kg/m^3
pound (avoirdupois) per cubic inch	lb/in^3	≡ lb/in^3	≈ 2.767 990 471 × 10^4 kg/m^3
pound (avoirdupois) per gallon (Imperial)	lb/gal	≡ lb/gal	≈ 99.776 372 66 kg/m^3
pound (avoirdupois) per gallon (U.S. fluid)	lb/gal	≡ lb/gal	≈ 119.826 4273 kg/m^3
slug per cubic foot	$slug/ft^3$	≡ $slug/ft^3$	≈ 515.378 8184 kg/m^3

Time

Time, t

Name of unit	Symbol	Definition	Relation to SI units
atomic unit of time	au	≡ $a_0/(\alpha \cdot c)$	≈ 2.418 884 254 × 10^{-17} s
Callippic cycle		≡ 441 mo (hollow) + 499 mo (full) = 76 a of 365.25 d	= 2.398 3776 × 10^9 s
century	c	≡ 100 a (see below for definition of year length)	= 100 × year
day	d	= 24 h	= 86 400 s
day (sidereal)	d	≡ Time needed for the Earth to rotate once around its axis, determined from successive transits of a very distant astronomical object across an observer's meridian (International Celestial Reference Frame)	≈ 86 164.1 s
decade	dec	≡ 10 a (see below for definition of year length)	= 10 × year
fortnight	fn	≡ 2 wk	= 1 209 600 s
helek		≡ 1/1 080 h	= 3.3 s
Hipparchic cycle		≡ 4 Callippic cycles - 1 d	= 9.593 424 × 10^9 s
hour	h	≡ 60 min	= 3 600 s
jiffy	j	≡ 1/60 s	= .016 s
jiffy (alternate)	ja	≡ 1/100 s	= 10 ms
ke (quarter of an hour)		≡ ¼ h = 1/96 d	= 60 × 60 / 4 s = 900 s = 60 / 4 min = 15 min
ke (traditional)		≡ 1/100 d	= 24 × 60 × 60 / 100 s = 864 s = 24 * 60 / 100 min = 14.4 min
lustre; lustrum		≡ 5 a of 365 d	= 1.5768 × 10^8 s

Metonic cycle; enneadecaeteris		≡ 110 mo (hollow) + 125 mo (full) = 6940 d ≈ 19 a	$= 5.996\ 16 \times 10^{8}$ s
millennium		≡ 1 000 a (see below for definition of year length)	= 1000 × year
milliday	md	≡ 1/1 000 d	= 24 × 60 × 60 / 1 000 s = 86.4 s
minute	min	≡ 60 s, due to leap seconds sometimes 59 s or 61 s,	= 60 s
moment		≡ 90 s	= 90 s
month (full)	mo	≡ 30 d[20]	= 2 592 000 s
month (Greg. av.)	mo	Average Gregorian month = 365.2425/12 d = 30.436875 d	$\approx 2.6297 \times 10^{6}$ s
month (hollow)	mo	≡ 29 d[20]	= 2 505 600 s
month (synodic)	mo	Cycle time of moon phases ≈ 29.530589 days (Average)	$\approx 2.551 \times 10^{6}$ s
octaeteris		= 48 mo (full) + 48 mo (hollow) + 3 mo (full)[21][22] = 8 a of 365.25 d = 2922 d	$= 2.524\ 608 \times 10^{8}$ s
Planck time		$\equiv (G\hbar/c^{5})^{1/2}$	$\approx 1.351\ 211\ 868 \times 10^{-43}$ s
second	s	time of 9 192 631 770 periods of the radiation corresponding to the transition between the 2 hyperfine levels of the ground state of the caesium 133 atom at 0 K[8] (but other seconds are sometimes used in astronomy)	(SI base unit)
shake		$\equiv 10^{-8}$ s	= 10 ns
sigma		$\equiv 10^{-6}$ s	= 1 μs
Sothic cycle		≡ 1 461 a of 365 d	$= 4.607\ 4096 \times 10^{10}$ s
svedberg	S	$\equiv 10^{-13}$ s	= 100 fs
week	wk	≡ 7 d	= 604 800 s
year (Gregorian)	a, y, *or* yr	= 365.2425 d average, calculated from common years (365 d) plus leap years (366 d) on most years divisible by 4. See leap year for details.	= 31 556 952 s
year (Julian)	a, y, *or* yr	= 365.25 d average, calculated from common years (365 d) plus one leap year (366 d) every four years	= 31 557 600 s
year (sidereal)	a, y, *or* yr	≡ time taken for Sun to return to the same position with respect to the stars of the celestial sphere	≈ 365.256 363 d ≈ 31 558 149.7632 s
		≡ Length of time it takes for the Sun to	

year (tropical)	a, y, *or* yr	return to the same position in the cycle of seasons	≈ 365.242 190 d ≈ 31 556 925 s
Where UTC is observed, the length of time units longer than 1 s may increase or decrease by 1 s if a leap second occurs during the time interval of interest.			

Frequency

Frequency

Name of unit	Symbol	Definition	Relation to SI units
hertz (SI unit)	Hz	≡ Number of cycles per second	= 1 Hz = 1/s
revolutions per minute	rpm	≡ One unit rpm equals one rotation completed around a fixed axis in one minute of time.	≈ 0.104 719 755 rad/s

Speed or velocity

distance/time

Speed

Name of unit	Symbol	Definition	Relation to SI units
foot per hour	fph	≡ 1 ft/h	≈ $8.466\,667 \times 10^{-5}$ m/s
foot per minute	fpm	≡ 1 ft/min	= 5.08×10^{-3} m/s
foot per second	fps	≡ 1 ft/s	= 3.048×10^{-1} m/s
furlong per fortnight		≡ furlong/fortnight	≈ $1.663\,095 \times 10^{-4}$ m/s
inch per minute	ipm	≡ 1 in/min	≈ $4.23\,333 \times 10^{-4}$ m/s
inch per second	ips	≡ 1 in/s	= 2.54×10^{-2} m/s
kilometre per hour	km/h	≡ 1 km/h	≈ $2.777\,778 \times 10^{-1}$ m/s
knot	kn	≡ 1 NM/h = 1.852 km/h	≈ 0.514 444 m/s
knot (Admiralty)	kn	≡ 1 NM (Adm)/h = 1.853 184 km/h[*citation needed*]	= $0.514\,77\overline{3}$ m/s
mach number	*M*	Ratio of the speed to the speed of sound in the medium. Varies especially with temperature. About 761 mph (1225 kph) in air at sea level to about 660 mph (1062 kph) at jet altitudes. Unitless	≈ 340 to 295 m/s for aircraft
metre per second (SI unit)	m/s	≡ 1 m/s	= 1 m/s

mile per hour	mph	≡ 1 mi/h	= 0.447 04 m/s
mile per minute	mpm	≡ 1 mi/min	= 26.8224 m/s
mile per second	mps	≡ 1 mi/s	= 1 609.344 m/s
speed of light in vacuum	*c*	≡ 299 792 458 m/s	= 299 792 458 m/s
speed of sound in air	*s*	Varies especially with temperature. About 761 mph (1225 kph) in air at sea level to about 660 mph (1062 kph) at jet altitudes.	≈ 340 to 295 m/s at aircraft altitudes

A velocity consists of a speed combined with a direction; the speed part of the velocity takes units of speed.

Flow (volume)

Flow

Name of unit	Symbol	Definition	Relation to SI units
cubic foot per minute	CFM	≡ 1 ft^3/min	= 4.719 474 432 × 10^{-4} m^3/s
cubic foot per second	ft^3/s	≡ 1 ft^3/s	= 0.028 316 846 592 m^3/s
cubic inch per minute	in^3/min	≡ 1 in^3/min	= 2.731 1773 × 10^{-7} m^3/s
cubic inch per second	in^3/s	≡ 1 in^3/s	= 1.638 7064 × 10^{-5} m^3/s
cubic metre per second (SI unit)	m^3/s	≡ 1 m^3/s	= 1 m^3/s
gallon (U.S. fluid) per day	GPD	≡ 1 gal/d	= 4.381 263 638 × 10^{-8} m^3/s
gallon (U.S. fluid) per hour	GPH	≡ 1 gal/h	= 1.051 503 273 × 10^{-6} m^3/s
gallon (U.S. fluid) per minute	GPM	≡ 1 gal/min	= 6.309 019 64 × 10^{-5} m^3/s
litre per minute	LPM	≡ 1 L/min	= 1.6 × 10^{-5} m^3/s

Acceleration

Acceleration

Name of unit	Symbol	Definition	Relation to SI units
foot per hour per second	fph/s	≡ 1 ft/(h·s)	≈ 8.466 667 × 10^{-5} m/s^2
foot per minute per second	fpm/s	≡ 1 ft/(min·s)	= 5.08 × 10^{-3} m/s^2
foot per second squared	fps^2	≡ 1 ft/s^2	= 3.048 × 10^{-1} m/s^2
gal; galileo	Gal	≡ 1 cm/s^2	= 10^{-2} m/s^2
inch per minute per second	ipm/s	≡ 1 in/(min·s)	≈ 4.233 333 × 10^{-4} m/s^2
inch per second squared	ips^2	≡ 1 in/s^2	= 2.54 × 10^{-2} m/s^2

knot per second	kn/s	≡ 1 kn/s	≈ 5.144 444 × 10^{-1} m/s^2
metre per second squared (SI unit)	m/s^2	≡ 1 m/s^2	= 1 m/s^2
mile per hour per second	mph/s	≡ 1 mi/(h·s)	= 4.4704 × 10^{-1} m/s^2
mile per minute per second	mpm/s	≡ 1 mi/(min·s)	= 26.8224 m/s^2
mile per second squared	mps^2	≡ 1 mi/s^2	= 1.609 344 × 10^3 m/s^2
standard gravity	g	≡ 9.806 65 m/s^2	= 9.806 65 m/s^2

Force

Force

Name of unit	Symbol	Definition	Relation to SI units
atomic unit of force		$\equiv m_e \cdot \alpha^2 \cdot c^2 / a_0$	≈ 8.238 722 06 × 10^{-8} N [23]
dyne (cgs unit)	dyn	≡ g·cm/s^2	= 10^{-5} N
kilogram-force; kilopond; grave-force	kgf; kp; Gf	≡ g × 1 kg	= 9.806 65 N
kip; kip-force	kip; kipf; klbf	≡ g × 1 000 lb	= 4.448 221 615 2605 × 10^3 N
milligrave-force, gravet-force	mGf; gf	≡ g × 1 g	= 9.806 65 mN
newton (SI unit)	N	A force capable of giving a mass of one kg an acceleration of one metre per second, per second.[24]	= 1 N = 1 kg·m/s^2
ounce-force	ozf	≡ g × 1 oz	= 0.278 013 850 953 7812 N
pound	lb	≡ slug·ft/s^2	= 4.448 230 531 N
pound-force	lbf	≡ g × 1 lb	= 4.448 221 615 2605 N
poundal	pdl	≡ 1 lb·ft/s^2	= 0.138 254 954 376 N
sthene (mts unit)	sn	≡ 1 t·m/s^2	= 1 × 10^3 N
ton-force	tnf	≡ g × 1 sh tn	= 8.896 443 230 521 × 10^3 N

See also: Conversion between weight (force) and mass

Pressure or mechanical stress

Pressure

Name of unit	Symbol	Definition	Relation to SI units
atmosphere (standard)	atm		≡ 101 325 Pa [25]
atmosphere (technical)	at	≡ 1 kgf/cm^2	= 9.806 65 × 10^4 Pa [25]
bar	bar		≡ 10^5 Pa
barye (cgs unit)		≡ 1 dyn/cm^2	= 0.1 Pa
centimetre of mercury	cmHg	≡ 13 595.1 kg/m^3 × 1 cm × g	≈ 1.333 22 × 10^3 Pa [25]
centimetre of water (4 °C)	cmH_2O	≈ 999.972 kg/m^3 × 1 cm × g	≈ 98.0638 Pa [25]
foot of mercury (conventional)	ftHg	≡ 13 595.1 kg/m^3 × 1 ft × g	≈ 40.636 66 × 10^3 Pa [25]
foot of water (39.2 °F)	ftH_2O	≈ 999.972 kg/m^3 × 1 ft × g	≈ 2.988 98 × 10^3 Pa [25]
inch of mercury (conventional)	inHg	≡ 13 595.1 kg/m^3 × 1 in × g	≈ 3.386 389 × 10^3 Pa [25]
inch of water (39.2 °F)	inH_2O	≈ 999.972 kg/m^3 × 1 in × g	≈ 249.082 Pa [25]
kilogram-force per square millimetre	kgf/mm^2	≡ 1 kgf/mm^2	= 9.806 65 × 10^6 Pa [25]
kip per square inch	ksi	≡ 1 kipf/sq in	≈ 6.894 757 × 10^6 Pa [25]
micron (micrometre) of mercury	μmHg	≡ 13 595.1 kg/m^3 × 1 μm × g ≈ 0.001 torr	≈ 0.133 3224 Pa [25]
millimetre of mercury	mmHg	≡ 13 595.1 kg/m^3 × 1 mm × g ≈ 1 torr	≈ 133.3224 Pa [25]
millimetre of water (3.98 °C)	mmH_2O	≈ 999.972 kg/m^3 × 1 mm × g = 0.999 972 kgf/m^2	= 9.806 38 Pa
pascal (SI unit)	Pa	≡ N/m^2 = $kg/(m{\cdot}s^2)$	= 1 Pa [26]
pièze (mts unit)	pz	≡ 1 000 $kg/m{\cdot}s^2$	= 1 × 10^3 Pa = 1 kPa
pound per square foot	psf	≡ 1 lbf/ft^2	≈ 47.880 25 Pa [25]
pound per square inch	psi	≡ 1 lbf/in^2	≈ 6.894 757 × 10^3 Pa [25]
poundal per square foot	pdl/sq ft	≡ 1 pdl/sq ft	≈ 1.488 164 Pa [25]
short ton per square foot		≡ 1 sh tn × g / 1 sq ft	≈ 95.760 518 × 10^3 Pa
torr	torr	≡ 101 325/760 Pa	≈ 133.3224 Pa [25]

Torque or moment of force

Torque			
Name of unit	**Symbol**	**Definition**	**Relation to SI units**
foot-pound force	ft lbf	$\equiv g \times 1$ lb × 1 ft	= 1.355 817 948 331 4004 N·m
foot-poundal	ft pdl	≡ 1 lb·ft^2/s^2	= 4.214 011 009 380 48 × 10^{-2} N·m
inch-pound force	in lbf	$\equiv g \times 1$ lb × 1 in	= 0.112 984 829 027 6167 N·m
metre kilogram	m kg	≡ N × m / g	≈ 0.101 971 621 N·m
Newton metre (SI unit)	N·m	≡ N × m = kg·m^2/s^2	= 1 N·m

Energy, work, or amount of heat

Energy			
Name of unit	**Symbol**	**Definition**	**Relation to SI units**
barrel of oil equivalent	bboe	≈ 5.8 × 10^6 BTU$_{59\ °F}$	≈ 6.12 × 10^9 J
British thermal unit (ISO)	BTU$_{ISO}$	≡ 1.0545 × 10^3 J	= 1.0545 × 10^3 J
British thermal unit (International Table)	BTU$_{IT}$		= 1.055 055 852 62 × 10^3 J
British thermal unit (mean)	BTU$_{mean}$		≈ 1.055 87 × 10^3 J
British thermal unit (thermochemical)	BTU$_{th}$		≈ 1.054 350 × 10^3 J
British thermal unit (39 °F)	BTU$_{39\ °F}$		≈ 1.059 67 × 10^3 J
British thermal unit (59 °F)	BTU$_{59\ °F}$	≡ 1.054 804 × 10^3 J	= 1.054 804 × 10^3 J
British thermal unit (60 °F)	BTU$_{60\ °F}$		≈ 1.054 68 × 10^3 J
British thermal unit (63 °F)	BTU$_{63\ °F}$		≈ 1.0546 × 10^3 J
calorie (International Table)	cal$_{IT}$	≡ 4.1868 J	= 4.1868 J
calorie (mean)	cal$_{mean}$		≈ 4.190 02 J
calorie (thermochemical)	cal$_{th}$	≡ 4.184 J	= 4.184 J
calorie (3.98 °C)	cal$_{3.98\ °C}$		≈ 4.2045 J
calorie (15 °C)	cal$_{15\ °C}$	≡ 4.1855 J	= 4.1855 J
calorie (20 °C)	cal$_{20\ °C}$		≈ 4.1819 J

Celsius heat unit (International Table)	CHU_{IT}	$\equiv 1\ BTU_{IT} \times 1\ K/°R$	$= 1.899\ 100\ 534\ 716 \times 10^3$ J
cubic centimetre of atmosphere; standard cubic centimetre	cc atm; scc	$\equiv 1$ atm × 1 cm^3	= 0.101 325 J
cubic foot of atmosphere; standard cubic foot	cu ft atm; scf	$\equiv 1$ atm × 1 ft^3	$= 2.869\ 204\ 480\ 9344 \times 10^3$ J
cubic foot of natural gas		$\equiv 1\ 000\ BTU_{IT}$	$= 1.055\ 055\ 852\ 62 \times 10^6$ J
cubic yard of atmosphere; standard cubic yard	cu yd atm; scy	$\equiv 1$ atm × 1 yd^3	$= 77.468\ 520\ 985\ 2288 \times 10^3$ J
electronvolt	eV	$\equiv e \times 1$ V	$\approx 1.602\ 177\ 33 \times 10^{-19} \pm 4.9 \times 10^{-26}$ J
erg (cgs unit)	erg	$\equiv 1\ g{\cdot}cm^2/s^2$	$= 10^{-7}$ J
foot-pound force	ft lbf	$\equiv g \times 1$ lb × 1 ft	= 1.355 817 948 331 4004 J
foot-poundal	ft pdl	$\equiv 1\ lb{\cdot}ft^2/s^2$	$= 4.214\ 011\ 009\ 380\ 48 \times 10^{-2}$ J
gallon-atmosphere (imperial)	imp gal atm	$\equiv 1$ atm × 1 gal (imp)	= 460.632 569 25 J
gallon-atmosphere (US)	US gal atm	$\equiv 1$ atm × 1 gal (US)	= 383.556 849 0138 J
hartree, atomic unit of energy	E_h	$\equiv m_e{\cdot}\alpha^2{\cdot}c^2$ (= 2 Ry)	$\approx 4.359\ 744 \times 10^{-18}$ J
horsepower-hour	hp·h	$\equiv 1$ hp × 1 h	$= 2.684\ 519\ 537\ 696\ 172\ 792 \times 10^6$ J
inch-pound force	in lbf	$\equiv g \times 1$ lb × 1 in	= 0.112 984 829 027 6167 J
joule (SI unit)	J	The work done when a force of one newton moves the point of its application a distance of one metre in the direction of the force.[24]	$= 1\ J = 1\ m{\cdot}N = 1\ kg{\cdot}m^2/s^2$
kilocalorie; large calorie	kcal; Cal	$\equiv 1\ 000\ cal_{IT}$	$= 4.1868 \times 10^3$ J
kilowatt-hour; Board of Trade Unit	kW·h; B.O.T.U.	$\equiv 1$ kW × 1 h	$= 3.6 \times 10^6$ J
litre-atmosphere	l atm; sl	$\equiv 1$ atm × 1 L	= 101.325 J
quad		$\equiv 10^{15}\ BTU_{IT}$	$= 1.055\ 055\ 852\ 62 \times 10^{18}$ J
rydberg	Ry	$\equiv R_\infty{\cdot}h{\cdot}c$	$\approx 2.179\ 872 \times 10^{-18}$ J

therm (E.C.)		$\equiv 100\,000$ BTU_{IT}	$= 105.505\,585\,262 \times 10^6$ J
therm (U.S.)		$\equiv 100\,000$ $BTU_{59\,°F}$	$= 105.4804 \times 10^6$ J
thermie	th	$\equiv 1$ $Mcal_{IT}$	$= 4.1868 \times 10^6$ J
ton of coal equivalent	TCE	$\equiv 7$ $Gcal_{th}$	$= 29.3076 \times 10^9$ J
ton of oil equivalent	TOE	$\equiv 10$ $Gcal_{th}$	$= 41.868 \times 10^9$ J
ton of TNT	tTNT	$\equiv 1$ $Gcal_{th}$	$= 4.184 \times 10^9$ J

Power or heat flow rate

Power

Name of unit	Symbol	Definition	Relation to SI units
atmosphere-cubic centimetre per minute	atm ccm	$\equiv 1$ atm × 1 cm^3/min	$= 1.688\,75 \times 10^{-3}$ W
atmosphere-cubic centimetre per second	atm ccs	$\equiv 1$ atm × 1 cm^3/s	$= 0.101\,325$ W
atmosphere-cubic foot per hour	atm cfh	$\equiv 1$ atm × 1 cu ft/h	$= 0.797\,001\,244\,704$ W
atmosphere-cubic foot per minute	atm·cfm	$\equiv 1$ atm × 1 cu ft/min	$= 47.820\,074\,682\,24$ W
atmosphere-cubic foot per second	atm cfs	$\equiv 1$ atm × 1 cu ft/s	$= 2.869\,204\,480\,9344 \times 10^3$ W
BTU (International Table) per hour	BTU_{IT}/h	$\equiv 1$ BTU_{IT}/h	$\approx 0.293\,071$ W
BTU (International Table) per minute	BTU_{IT}/min	$\equiv 1$ BTU_{IT}/min	$\approx 17.584\,264$ W
BTU (International Table) per second	BTU_{IT}/s	$\equiv 1$ BTU_{IT}/s	$= 1.055\,055\,852\,62 \times 10^3$ W
calorie (International Table) per second	cal_{IT}/s	$\equiv 1$ cal_{IT}/s	$= 4.1868$ W
foot-pound-force per hour	ft lbf/h	$\equiv 1$ ft lbf/h	$\approx 3.766\,161 \times 10^{-4}$ W
foot-pound-force per minute	ft lbf/min	$\equiv 1$ ft lbf/min	$= 2.259\,696\,580\,552\,334 \times 10^{-2}$ W
foot-pound-force per second	ft lbf/s	$\equiv 1$ ft lbf/s	$= 1.355\,817\,948\,331\,4004$ W
horsepower (boiler)	bhp	≈ 34.5 lb/h × 970.3 BTU_{IT}/lb	$\approx 9.810\,657 \times 10^3$ W
horsepower (European electrical)	hp	$\equiv 75$ kp·m/s	$= 736$ W
horsepower (Imperial			

electrical)	hp	≡ 746 W	= 746 W
horsepower (Imperial mechanical)	hp	≡ 550 ft lbf/s	= 745.699 871 582 270 22 W
horsepower (metric)	hp	≡ 75 m kgf/s	= 735.498 75 W
litre-atmosphere per minute	L·atm/min	≡ 1 atm × 1 L/min	= 1.688 75 W
litre-atmosphere per second	L·atm/s	≡ 1 atm × 1 L/s	= 101.325 W
lusec	lusec	≡ 1 L·µmHg/s [14]	≈ 1.333×10^{-4} W
poncelet	p	≡ 100 m kgf/s	= 980.665 W
square foot equivalent direct radiation	sq ft EDR	≡ 240 BTU_{IT}/h	≈ 70.337 057 W
ton of air conditioning		≡ 1 t ice melted / 24 h	≈ 3 504 W
ton of refrigeration (Imperial)		≡ 1 BTU_{IT} × 1 lng tn/lb ÷ 10 min/s	≈ $3.938\ 875 \times 10^3$ W
ton of refrigeration (IT)		≡ 1 BTU_{IT} × 1 sh tn/lb ÷ 10 min/s	≈ $3.516\ 853 \times 10^3$ W
watt (SI unit)	W	The power which in one second of time gives rise to one joule of energy.[24]	= 1 W = 1 J/s = 1 N·m/s = 1 kg·m²/s³

Action

Action

Name of unit	Symbol	Definition	Relation to SI units
atomic unit of action	au	$\equiv \hbar \equiv h/2\pi$	≈ $1.054\ 571\ 68 \times 10^{-34}$ J·s[27]

Dynamic viscosity

Dynamic viscosity

Name of unit	Symbol	Definition	Relation to SI units
pascal second (SI unit)	Pa·s	≡ N·s/m² , kg/(m·s)	= 1 Pa·s
poise (cgs unit)	P	≡ 10^{-1} Pa·s	= 0.1 Pa·s
pound per foot hour	lb/(ft·h)	≡ 1 lb/(ft·h)	≈ $4.133\ 789 \times 10^{-4}$ Pa·s
pound per foot second	lb/(ft·s)	≡ 1 lb/(ft·s)	≈ 1.488 164 Pa·s
pound-force second per square foot	lbf·s/ft²	≡ 1 lbf·s/ft²	≈ 47.880 26 Pa·s
pound-force second per square inch	lbf·s/in²	≡ 1 lbf·s/in²	≈ 6,894.757 Pa·s

Kinematic viscosity

Kinematic viscosity

Name of unit	Symbol	Definition	Relation to SI units
square foot per second	ft^2/s	≡ 1 ft^2/s	= 0.092 903 04 m^2/s
square metre per second (SI unit)	m^2/s	≡ 1 m^2/s	= 1 m^2/s
stokes (cgs unit)	St	≡ 10^{-4} m^2/s	= 10^{-4} m^2/s

Electric current

Electric current

Name of unit	Symbol	Definition	Relation to SI units
ampere (SI base unit)	A	≡ The constant current needed to produce a force of 2 × 10^{-7} newton per metre between two straight parallel conductors of infinite length and negligible circular cross-section placed one metre apart in a vacuum.[8]	= 1 A
electromagnetic unit; abampere (cgs unit)	abamp	≡ 10 A	= 10 A
esu per second; statampere (cgs unit)	esu/s	≡ (0.1 A·m/s) / c	≈ 3.335 641 × 10^{-10} A

Electric charge

Electric charge

Name of unit	Symbol	Definition	Relation to SI units
abcoulomb; electromagnetic unit (cgs unit)	abC; emu	≡ 10 C	= 10 C
atomic unit of charge	au	≡ e	≈ 1.602 176 462 × 10^{-19} C
coulomb (SI unit)	C	≡ The amount of electricity carried in one second of time by one ampere of current.[24]	= 1 C = 1 A·s
faraday	F	≡ 1 mol × $N_A \cdot e$	≈ 96 485.3383 C
statcoulomb; franklin; electrostatic unit (cgs unit)	statC; Fr; esu	≡ (0.1 A·m) / c	≈ 3.335 641 × 10^{-10} C

Electric dipole

Electric dipole

Name of unit	Symbol	Definition	Relation to SI units
atomic unit of electric dipole moment	ea_0		≈ 8.478 352 81 × 10^{-30} C·m[28]

Electromotive force, electric potential difference

Voltage, electromotive force

Name of unit	Symbol	Definition	Relation to SI units
abvolt (cgs unit)	abV	≡ 1 × 10^{-8} V	= 1 × 10^{-8} V
statvolt (cgs unit)	statV	≡ c· (1 μJ/A·m)	= 299.792 458 V
volt (SI unit)	V	The difference in electric potential across two points along a conducting wire carrying one ampere of constant current when the power dissipated between the points equals one watt.[24]	= 1 V = 1 W/A = 1 kg·m^2/(A·s^3)

Electrical resistance

Electrical resistance

Name of unit	Symbol	Definition	Relation to SI units
ohm (SI unit)	Ω	The resistance between two points in a conductor when one volt of electric potential difference, applied to these points, produces one ampere of current in the conductor.[24]	= 1 Ω = 1 V/A = 1 kg·m^2/(A^2·s^3)

Capacitance

Capacitor's ability to store charge

Name of unit	Symbol	Definition	Relation to SI units
farad (SI unit)	F	The capacitance between two parallel plates that results in one volt of potential difference when charged by one coulomb of electricity.[24]	= 1 F = 1 C/V = 1 A^2·s^4/(kg·m^2)

Magnetic flux

magnetic flux

Name of unit	Symbol	Definition	Relation to SI units
maxwell (CGS unit)	Mx	≡ 10^{-8} Wb[29]	= 1 × 10^{-8} Wb

weber (SI unit)	Wb	Magnetic flux which, linking a circuit of one turn, would produce in it an electromotive force of 1 volt if it were reduced to zero at a uniform rate in 1 second.[24]	$= 1\ \text{Wb} = 1\ \text{V·s} = 1\ \text{kg·m}^2/(\text{A·s}^2)$

Magnetic flux density

What physicists call Magnetic field is called Magnetic flux density by electrical engineers and magnetic induction by applied mathematicians and electrical engineers.

Name of unit	Symbol	Definition	Relation to SI units
gauss (CGS unit)	G	$\equiv \text{Mx/cm}^2 = 10^{-4}\ \text{T}$	$= 1 \times 10^{-4}\ \text{T}$ [30]
tesla (SI unit)	T	$\equiv \text{Wb/m}^2$	$= 1\ \text{T} = 1\ \text{Wb/m}^2 = 1\ \text{kg/(A·s}^2)$

Inductance

Inductance

Name of unit	Symbol	Definition	Relation to SI units
henry (SI unit)	H	The inductance of a closed circuit that produces one volt of electromotive force when the current in the circuit varies at a uniform rate of one ampere per second.[24]	$= 1\ \text{H} = 1\ \text{Wb/A} = 1\ \text{kg·m}^2/(\text{A·s})^2$

Temperature

For more details on this topic, see Temperature conversion.

Temperature

Name of unit	Symbol	Definition	Conversion to kelvin
degree Celsius	°C	°C ≡ K − 273.15	[K] ≡ [°C] + 273.15
degree Delisle	°De		[K] = 373.15 − [°De] × 2/3
degree Fahrenheit	°F	°F ≡ °C × 9/5 + 32	[K] ≡ ([°F] + 459.67) × 5/9
degree Newton	°N		[K] = [°N] × 100/33 + 273.15
degree Rankine	°R; °Ra	°R ≡ K × 9/5	[K] ≡ [°R] × 5/9
degree Réaumur	°Ré		[K] = [°Ré] × 5/4 + 273.15
degree Rømer	°Rø		[K] = ([°Rø] − 7.5) × 40/21 + 273.15
kelvin (SI base unit)	K	≡ 1/273.16 of the thermodynamic temperature of the triple point of water.[8]	≡ 1 K

Information entropy

Information entropy

Name of unit	Symbol	Definition	Relation to SI units	Relation to bits
SI unit	J/K	≡ J/K	= 1 J/K	
nat; nip; nepit	nat	≡ k_B	= 1.380 650 5(23) × 10^{-23} J/K	
bit; shannon	bit; b; Sh	≡ ln(2) × k_B	= 9.569 940 (16) × 10^{-24} J/K	= 1 bit
ban; hartley	ban; Hart	≡ ln(10) × k_B	= 3.179 065 3(53) × 10^{-23} J/K	
nibble		≡ 4 bits	= 3.827 976 0(64) × 10^{-23} J/K	= 2^2 bit
byte	B	≡ 8 bits	= 7.655 952 (13) × 10^{-23} J/K	= 2^3 bit
kilobyte (decimal)	kB	≡ 1 000 B	= 7.655 952 (13) × 10^{-20} J/K	
kilobyte (kibibyte)	KB; KiB	≡ 1 024 B	= 7.839 695 (13) × 10^{-20} J/K	= 2^{10} bit

Often, information entropy is measured in shannons, whereas the (discrete) storage space of digital devices is measured in bits. Thus, uncompressed redundant data occupy more than one bit of storage per shannon of information entropy. The multiples of a bit listed above are usually used with this meaning. Other times the bit is used as a measure of information entropy and is thus a synonym of shannon.

Luminous intensity

The candela is the preferred nomenclature for the SI unit.

Luminous intensity

Name of unit	Symbol	Definition	Relation to SI units
candela (SI base unit); candle	cd	The luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 × 10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian.[8]	= 1 cd
candlepower (new)	cp	≡ cd The use of *candlepower* as a unit is discouraged due to its ambiguity.	= 1 cd
candlepower (old, pre-1948)	cp	Varies and is poorly reproducible.[31] Approximately 0.981 cd.[14]	≈ 0.981 cd

Luminance

Luminance

Name of unit	Symbol	Definition	Relation to SI units
candela per square foot	cd/ft^2	≡ cd/ft^2	≈ 10.763 910 417 cd/m^2
candela per square inch	cd/in^2	≡ cd/in^2	≈ 1,550.0031 cd/m^2

candela per square metre (SI unit); nit (deprecated [14])	cd/m^2	$\equiv cd/m^2$	$= 1\ cd/m^2$
footlambert	fL	$\equiv (1/\pi)\ cd/ft^2$	$\approx 3.426\ 259\ 0996\ cd/m^2$
lambert	L	$\equiv (10^4/\pi)\ cd/m^2$	$\approx 3{,}183.098\ 8618\ cd/m^2$
stilb (CGS unit)	sb	$\equiv 10^4\ cd/m^2$	$\approx 1 \times 10^4\ cd/m^2$

Luminous flux

Luminous flux

Name of unit	Symbol	Definition	Relation to SI units
lumen (SI unit)	lm	≡ cd·sr	= 1 lm = 1 cd·sr

Illuminance

Illuminance

Name of unit	Symbol	Definition	Relation to SI units
footcandle; lumen per square foot	fc	$\equiv lm/ft^2$	= 10.763 910 417 lx
lumen per square inch	lm/in^2	$\equiv lm/in^2$	≈ 1,550.0031 lx
lux (SI unit)	lx	$\equiv lm/m^2$	$= 1\ lx = 1\ lm/m^2$
phot (CGS unit)	ph	$\equiv lm/cm^2$	$= 1 \times 10^4\ lx$

Radiation - source activity

Radioactivity

Name of unit	Symbol	Definition	Relation to SI units
becquerel (SI unit)	Bq	≡ Number of disintegrations per second	= 1 Bq = 1/s
curie	Ci	$\equiv 3.7 \times 10^{10}$ Bq	$= 3.7 \times 10^{10}$ Bq [32]
rutherford (H)	rd	≡ 1 MBq	$= 1 \times 10^6$ Bq

Please note that although becquerel (Bq) and hertz (Hz) both ultimately refer to the same SI base unit (s^{-1}), Hz is used only for periodic phenomena, and Bq is only used for stochastic processes associated with radioactivity.[33]

Radiation - exposure

Radiation - exposure

Name of unit	Symbol	Definition	Relation to SI units

roentgen	R	1 R ≡ 2.58×10^{-4} C/kg[29]	= 2.58×10^{-4} C/kg

The roentgen is not a SI unit and the NIST strongly discourages its continued use.[34]

Radiation - absorbed dose

Radiation - absorbed dose

Name of unit	Symbol	Definition	Relation to SI units
gray (SI unit)	Gy	≡ 1 J/kg = 1 m^2/s^2 [35]	= 1 Gy
rad	rad	≡ 0.01 Gy[29]	= 0.01 Gy

Radiation - equivalent dose

Radiation - equivalent dose

Name of unit	Symbol	Definition	Relation to SI units
Röntgen equivalent man	rem	≡ 0.01 Sv	= 0.01 Sv
sievert (SI unit)	Sv	≡ 1 J/kg[33]	= 1 Sv

Although the definitions for sievert (Sv) and gray (Gy) would seem to indicate that they measure the same quantities, this is not the case. The effect of receiving a certain dose of radiation (given as Gy) is variable and depends on many factors, thus a new unit was needed to denote the biological effectiveness of that dose on the body; this is known as the equivalent dose and is shown in Sv. The general relationship between absorbed dose and equivalent dose can be represented as

$$H = Q \cdot D$$

where H is the equivalent dose, D is the absorbed dose, and Q is a dimensionless quality factor. Thus, for any quantity of D measured in Gy, the numerical value for H measured in Sv may be different.[36]

Software tools

Home and office computers come with converters in bundled spreadsheet applications or can access free converters via the Internet. Units and measurements can be easily converted using these tools, but only if the units are explicitly defined and the conversion is compatible (e.g., cmHg to kPa).

General commercial sources of converters

- Advanced electronic calculators have unit-conversion functionality.
- Spreadsheet programs usually provide conversion functions or formulas or the user can write their own.
- Commercial mathematical, scientific and technical applications often include converters.

See also

- Accuracy and precision
- English units
- False precision
- Imperial units
- International System of Units
- Mesures usuelles
- Metric system
- Natural units
- Rounding
- Significant figures
- Temperature conversion
- United States customary units
- Units conversion by factor-label
- Units of measurement

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External links

- British law: Units of measurement regulations 1995
- ConvertBuster Variety of conversion tools to convert easily.
- *How Many? A dictionary of units of measurement*
- NIST: Fundamental physical constants — Non-SI unitsPDF (35.7 KB)
- NIST Guide to SI Units Many conversion factors listed.
- Online Conversion Calculators Very extensive list of conversions from-to equivalent units.
- The Unified Code for Units of Measure
- Units, Symbols, and Conversions XML Dictionary
- Multilingual Online Conversion of Units
- Temperature Converter

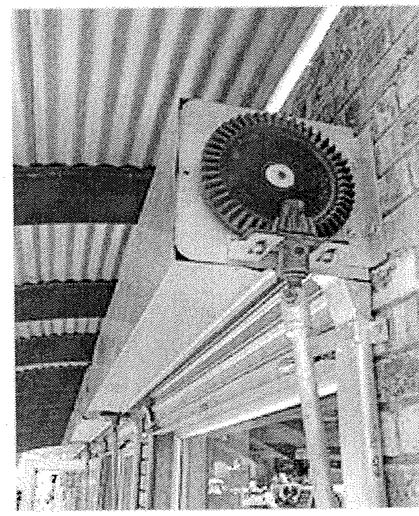
Appendix II

Bevel gear

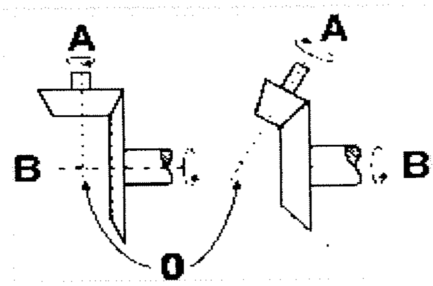
From Wikipedia, the free encyclopedia

Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone.

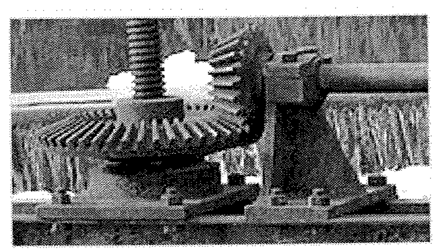
Contents



Bevel gear on roller shutter door.



Independently from the operating angle, the gear axes must intersect (at the point O)



Bevel gear lifts floodgate by means of central screw.

Introduction

Two important concepts in gearing are **pitch surface** and **pitch angle**. The pitch surface of a gear is the imaginary toothless surface that you would have by averaging out the peaks and valleys of the individual teeth. The pitch surface of an ordinary gear is the shape of a cylinder. The pitch angle of a gear is the angle between the face of the pitch surface and the axis.

The most familiar kinds of bevel gears have pitch angles of less than 90 degrees and therefore are cone-shaped. This type of bevel gear is called **external** because the gear teeth point outward. The pitch surfaces of meshed external bevel gears are coaxial with the gear shafts; the apexes of the two surfaces are at the point of intersection of the shaft axes.

Bevel gears that have pitch angles of greater than ninety degrees have teeth that point inward and are called **internal** bevel gears.

Bevel gears that have pitch angles of exactly 90 degrees have teeth that point outward parallel with the axis and resemble the points on a crown. That's why this type of bevel gear is called a **crown** gear.

Miter gears are mating bevel gears with equal numbers of teeth and with axes at right angles.

Skew bevel gears are those for which the corresponding crown gear

has teeth that are straight and oblique.

Teeth

There are two issues regarding tooth shape. One is the cross-sectional profile of the individual tooth. The other is the line or curve on which the tooth is set on the face of the gear: in other words the line or curve along which the cross-sectional profile is projected to form the actual three-dimensional shape of the tooth. The primary effect of both the cross-sectional profile and the tooth line or curve is on the smoothness of operation of the gears. Some result in a smoother gear action than others.

Tooth line

The teeth on bevel gears can be straight, spiral or "zero".

Straight tooth lines

In **straight bevel gears** the teeth are straight and parallel to the generators of the cone. This is the simplest form of bevel gear. It resembles a spur gear, only conical rather than cylindrical. The gears in the floodgate picture are straight bevel gears. In straight, when each tooth engages it impacts the corresponding tooth and simply curving the gear teeth can solve the problem.

Spiral tooth lines

Main article: spiral bevel gear

Spiral bevel gears have their teeth formed along spiral lines. They are somewhat analogous to cylindrical type helical gears in that the teeth are angled; however with spiral gears the teeth are also curved.

The advantage of the spiral tooth over the straight tooth is that they engage more gradually. The contact between the teeth starts at one end of the gear and then spreads across the whole tooth. This results in a less abrupt transfer of force when a new pair of teeth come in to play. With straight bevel gears, the abrupt tooth engagement causes noise, especially at high speeds, and impact stress on the teeth which makes them unable to take heavy loads at high speeds without breaking. For these reasons straight bevel gears are generally limited to use at linear speeds less than 1000 feet/min; or, for small gears, under 1000 r.p.m.[1]

Zero tooth lines

Zero bevel gears are an intermediate type between straight and spiral bevel gears. Their teeth are curved, but not angled.

Applications

The bevel gear has many diverse applications such as locomotives, marine applications, automobiles, printing presses, cooling towers, power plants, steel plants, railway track inspection machines, etc.

For examples, see the following articles on:

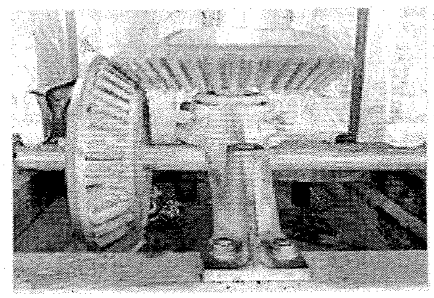
- Bevel gears are used in **differential drives**, which can transmit power to two axles spinning at different speeds, such as those on a cornering automobile.

- Bevel gears are used as the main mechanism for a **hand drill**. As the handle of the drill is turned in a vertical direction, the bevel gears change the rotation of the chuck to a horizontal rotation. The bevel gears in a hand drill have the added advantage of increasing the speed of rotation of the chuck and this makes it possible to drill a range of materials.

- The gears in a **bevel gear planer** permit minor adjustment during assembly and allow for some displacement due to deflection under operating loads without concentrating the load on the end of the tooth.

- Spiral bevel gears are important components on **rotorcraft** drive systems. These components are required to operate at high speeds, high loads, and for a large number of load cycles. In this application, spiral bevel gears are used to redirect the shaft from the horizontal gas turbine engine to the vertical rotor.

Advantages



Bevel gears on grain mill at Dordrecht. Note wooden teeth inserts on one of the gears.

- This gear makes it possible to change the operating angle.
- Differing of the number of teeth (effectively diameter) on each wheel allows mechanical advantage to be changed. By increasing or decreasing the ratio of teeth between the drive and driven wheels one may change the ratio of rotations between the two, meaning that the rotational drive and torque of the second wheel can be changed in relation to the first, with speed increasing and torque decreasing, or speed decreasing and torque increasing.

Disadvantages

- One wheel of such gear is designed to work with its complementary wheel and no other.
- Must be precisely mounted.
- The axes must be capable of supporting significant forces.

See also

- Gear
- Pitch cone
- Front cone
- Back cone

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Retrieved from "http://en.wikipedia.org/wiki/Bevel_gear"
Categories: Gears